THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

SELECTIVE DELIGNIFICATION OF WOOD AND OTHER FIBROUS MATERIALS: COMBUSTION OF SPENT LIQUOR

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Report Seventeen

A Progress Report

to

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C O N F I D E N T I A L

TABLE OF CONTENTS

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Appleton, Wisconsin

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SUMMARY

Studies on recovery have been limited to combustion of the spent liquor. The major effort was an attempt to demonstrate the feasibility of fluidized bed combustion in the face of the low melting Na_2CO_3-NaCl eutectic. Two runs were made on a 12-inch diameter pilot fluidized bed reactor at Dorr-Oliver. These tests were carried out with a simulated holopulp liquor prepared by adding hydrochloric acid and chlorine to a soda liquor to achieve the desired ratio of sodium to chlorine. Successful fluidized bed combustion was not demonstrated. The problem was bed defluidization at temperatures which were marginal for satisfactory combustion. Defluidization occurred with bed NaCl contents greater than 95% by weight. Dorr-Oliver does not recommend FluoSolids combustion for this liquor.

The tests at Dorr-Oliver indicated that the extent of chlorine emissions followed thermodynamic predictions. The only volatile chlorine compound detected was HCl and that only when the amount of chlorine in the feed exceeded the stoichiometric equivalent to the sodium. This is indicative that there should be no serious air emission problems with holopulp liquor combustion.

Work is currently underway in cooperation with Babcock & Wilcox to examine alternative methods of combustion for this liquor.

INTRODUCTION

Chemical recovery for holopulp was discussed at length in Progress Report Fifteen. It was concluded that a recovery process based on evaporation and burning of the liquor to produce sodium chloride and sodium carbonate, causticization of the carbonate, electrolytic processing of the chloride, and Day-Kesting ClO_2 production appeared workable.

Previous work on evaporation of holopulp liquor established that the chlorine compounds were not volatile under evaporating conditions. Condensates were free of chlorine but did contain a significant BOD load. No unusual behavior of the liquor during evaporation was observed. There was no strong foaming tendency nor evidence of precipitation up to about 30% solids.

The work on combustion described in Report Fifteen showed that sodium chloride and sodium carbonate were the only significant ash products from holopulp spent liquor. The only significant forms of volatile chlorine were hydrogen chloride and sodium chloride vapor. Attempts to demonstrate the feasibility of fluidized bed combustion were inconclusive. Ash fusion determinations of NaCl-Na_2CO_3 mixtures showed a definite region between about 25 and 60% NaCl where the fusion temperature was too low for fluidized bed combustion, but it appeared that outside this range fluidized bed burning might be tractable.

In addition, it was found that separation of NaCl from Na_2CO_3 by differential solubility appeared possible, and that there seemed to be no technical problems to ClO_2 generation.

Upon the conclusion of the work described in Report Fifteen, it appeared that a workable recovery system was attainable and that the greatest degree of uncertainty lay with the combustion step.

COMBUSTION

Combustion of liquor containing sodium and chlorine as the major ash constituents is the recovery step farthest removed from available technology. It was felt necessary to demonstrate successful combustion of holopulp spent liquor before considering work on recovery complete.

There appeared to be several process advantages to the use of fluidized bed incineration in holopulp recovery. Equilibrium calculations indicated that air emissions were lower at lower temperatures. This is especially true of NaCl vapor and subsequent salt carryover. Carrying out the combustion at temperatures below the melting point of the ash would avoid smelt-water problems and would also permit leaching Na_2CO_3 from the recovered material. A fluidized bed furnace would permit savings in capital compared to a conventional recovery furnace. It could also decrease evaporator requirements since indirect evaporators would only need to raise the solids content to 30-35%. A direct contact evaporator-scrubber would then be used to achieve firing concentrations. The final advantage lay in the fact that fluidized bed incinerators are in use in the industry so that the necessary technology has already been developed. It was recognized that NaCl and Na_2CO_3 form a low-melting eutectic which could prevent successful fluidized bed operation, but it was concluded that the potential advantages of fluidized bed combustion justified the risks. Accordingly, study of fluidized bed combustion was given first priority in this program.

There were three things that were regarded as critical for fluidized bed combustion:

1. Whether or not satisfactory combustion could be obtained at temperatures below the defluidization temperature.
2. Whether or not air emissions of chlorine compounds could be prevented or controlled with a simple scrubber.

3. Whether or not the recovered inorganics have the proper characteristics to permit a self-generated bed.

The evaluation of the feasibility of fluidized bed combustion was to be done in cooperation with the suppliers of that type of equipment.

PROPOSED WORK

The objectives of the current program on combustion of spent liquor were threefold.

1. To determine the conditions which permit complete combustion with no emissions or satisfactory control of emissions.

2. To demonstrate on a suitable pilot apparatus that holopulp liquors can be successfully burned in a fluidized bed.

3. To provide sufficient back-up information on alternative means of combustion if fluidized bed combustion proves unfeasible.

The initial effort was to be directed toward establishing the feasibility of fluidized bed combustion. Long-duration trials on pilot equipment at Dorr-Oliver or Copeland were to be carried out with simulated liquors. If these trials demonstrated the ability to maintain a fluidized bed at combustion temperature, we planned to rebuild our own unit and do the bulk of the work on air emissions at the Institute. If fluidized bed combustion could not be demonstrated, then it would be necessary to examine alternatives in cooperation with suppliers of combustion equipment.

FLUIDIZED BED FEASIBILITY STUDIES

It was apparent from the start that the critical problem regarding fluidized beds lay with the low fusion temperature of the ash. A phase diagram of the NaCl-Na_2CO_3 system furnished us by Dorr-Oliver indicated the formation of a eutectic at 44% NaCl and 56% Na_2CO_3 which melts at 1177°C. Our own melting point data, reported in Progress Report Fifteen, confirmed the eutectic and showed a distinct region from about 20 to 60% NaCl where the melting point was greatly lowered. However, our data indicated melting points above 1400°F. for ash compositions greater than 60% NaCl. It appeared that fluidized bed combustion of liquor was possible in this region.

A meeting was held with representatives of Dorr-Oliver in February to discuss the general problem of fluidized bed combustion of holopulp liquor and the possibility of a pilot testing program. A contact with Copeland Systems Inc. was also made at that time; however, it was not pursued because Copeland felt this involved an area in which they had a proprietary interest.

During the discussions with Dorr-Oliver, it became evident that fluidized bed combustion with large amounts of Na_2CO_3 in the ash would be very difficult. They explained that the type of melting point data which we had obtained (based on cone slumping and melting) was not really relevant to pellet growth in a fluidized bed. When a eutectic exists in a system, the amount of material corresponding to the eutectic melts and there is a liquid-solid mixture whose properties determine pellet growth and defluidization. Thus, in an ash containing 5% Na_2CO_3 and 95% NaCl, all of the Na_2CO_3 would form eutectic and melt taking with it 44/56 x 5% of the NaCl. In this situation, 9% of the material would be in the molten state. The feeling of the Dorr-Oliver people was that we would have great difficulty in

getting fluidized bed incineration with liquors having a chlorine/sodium ratio less than that corresponding to 90% NaCl and 10% Na_2CO_3.

The fact that fluidized bed combustion might be limited to ash compositions of 90% NaCl or higher was not too disturbing. This was despite the fact that current pulping conditions lead to ash compositions near 70% NaCl. It was felt that high NaCl ash liquors could be obtained by replacing some ClO_2 with Cl_2 in the pulping operations.

It was decided that our objectives could be met in a test program involving two 24-hr. runs. The first test was to be carried out with a liquor whose ash composition was at least 98% NaCl. The test would begin with a bed of NaCl particles. Liquor would be fired at 1200°F. until the bulk of the bed consisted of liquor ash. When the bed had been turned over a few times, the temperature was to be slowly increased to 1350°F. or until the bed fused. The second test was also to be started with a bed of NaCl particles. The liquor was to be doped with Na_2CO_3 to give an ash composition of 90% NaCl and 10% Na_2CO_3. The doped liquor would be fired at 1200°F. for about 24 hr. until the displacement would convert the system to 90% NaCl. If the bed had not defluidized up to this point, the temperature would be raised to determine the defluidization temperature.

PREPARATION OF LIQUOR

The test program outlined above required about 4000 lb. of 50%-solids liquor. It was out of the question to produce this amount of liquor by scaled-up holopulping and thus it was necessary to use a simulated spent liquor for the tests. In deciding on the requirements for a simulated liquor, the following were felt to be important:

1. The liquor should contain the proper proportions of sodium and chlorine and not be contaminated with other inorganic elements.

2. The heating value should be approximately the same as holopulp liquor.

3. The organic constituents should be similar to those expected in the pulping liquor.

4. There should be some organic chlorine compounds present.

When considering all of the possibilities of preparing a liquor and the amount of liquor needed, it was decided that the best route was to start with a soda cook hardwood spent liquor and add HCl and chlorine to it. Hydrochloric acid would be used to supply the bulk of the chlorine needed and the addition of chlorine was to be used to form organic compounds.

A small sample of soda liquor was obtained from a mill. Analysis showed the ash to consist essentially of Na_2CO_3 with a negligible amount of sulfur present. Laboratory runs indicated that it was feasible to add chlorine and hydrochloric acid to the liquor although there was some trouble with foaming. These lab tests indicated that it was best to add HCl first until all CO_2 was driven off before adding chlorine. When it appeared that we could prepare the simulated liquor in this manner, we asked the mill to send us 10 barrels of 50%-solids liquor.

Ten barrels of liquor were obtained which tested out at 60.9% solids and 17.1% sodium (based on the solids). Subsequently, it was learned that the sodium measurement was low because of a defective instrument. The liquor shipped to Dorr-Oliver contained an excess of sodium and it was necessary for them to add hydrochloric acid to achieve the desired proportion of sodium and chlorine. The liquor was prepared in two batches. Initially, it was desired to add about 2/3 of the total chlorine as HCl and the remainder as chlorine gas. No difficulty was experienced in adding the hydrochloric acid. However, the rate of reaction with chlorine was very slow. After several attempts to increase the rate had failed, it was decided to add all of the necessary chlorine as HCl. The liquor prepared in this manner

met all of the requirements for a simulated liquor except for the lack of organic chlorine compounds.

The physical properties of the liquor prepared in this manner were not typical of the properties of conventional spent liquors. They also appeared somewhat different from the true holopulp liquors we had made earlier although we had not worked at as high a solids content. The liquor acted like a suspension of solid particles. The viscosity was much lower than for conventional liquors and was not strongly dependent on temperature. On the other hand, the particles would settle on standing to form a dense material difficult to redisperse. It is believed that these properties were due to the method of forming the liquor. Strong acid was added to an originally alkaline liquor until the pH dropped to 3 or lower. This change from alkaline to acid conditions could destabilize the organic colloids present in the original liquor and hence lead to precipitation. It was recognized that this behavior of the liquor might not be typical of holopulp liquor; however, it was felt that it would not affect the validity of the tests.

TEST EQUIPMENT

The tests were carried out in the Dorr-Oliver laboratories at Stamford, Connecticut. A schematic diagram of the laboratory FluoSolids reactor used is shown in Fig. 1. It consists of a 12-inch i.d. stainless steel tube 9 ft. long, mounted vertically inside an insulation-type fire brick chimney. The tube is heated externally by hot combustion gas from four Maxon burners supplied by a ring manifold as shown. The object is to bring the unit up to operating temperature, to hold the fluidized bed at reaction temperature, and to offset radiation losses.

The fluidizing gas mixture is preheated in a Dutch oven and introduced into the bottom of the reactor through a windbox equipped with three tuyeres to

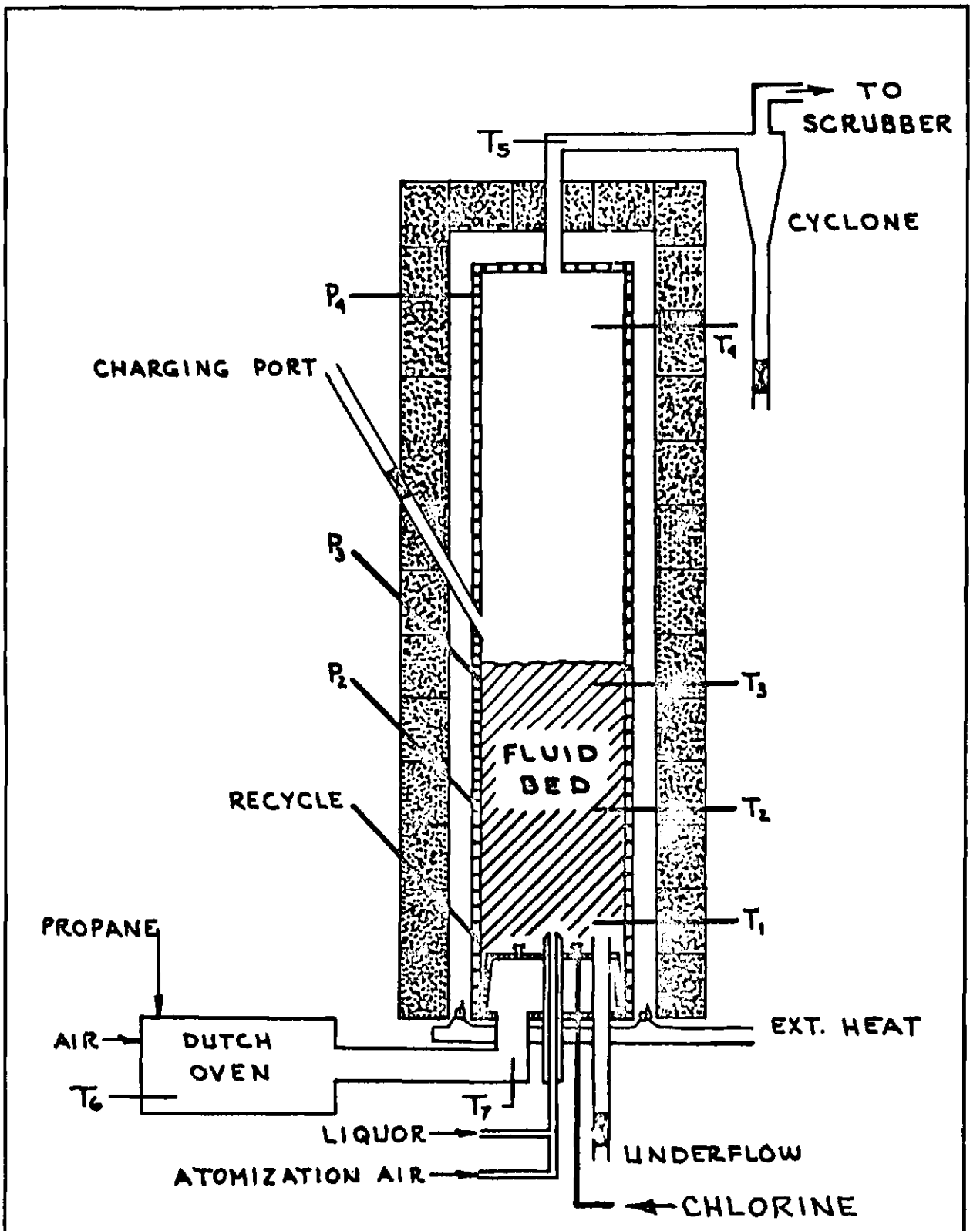

Figure 1

SCALE: NONE	TITLE	DORR-OLIVER
BY: P.R.R.	TWELVE INCH REACTOR WITH COLD CYCLONE	
DATE: 7-6-70		

distribute the gas evenly and to prevent run-back of solids on shutdown. The Dutch oven consists of a small refractory-lined tank in which propane and air are ignited with a spark. The products from this combination are then mixed with a portion of the total air going into the reactor.

The liquor is metered by means of a Moyno 2L2 pump and is picked up by a portion of the fluidizing air and conveyed to the bottom of the reactor, where it enters through a water-jacketed gun, 3/8 in. i.d., at a point 4 inches above the tuyeres.

Provisions were also made for injecting chlorine gas into the bed at a point 2 inches above the tuyeres through an injection gun.

Rotameters are used to measure the flows of air, propane, and chlorine. A panel board carried manometers connected to pressure taps $P_1 \rightarrow P_8$ and a pyrometer connected through a multipoint switch to thermocouples $T_1 \rightarrow T_7$ as shown in Fig. 1.

The reacted material is discharged partly as "underflow" through a bottom underflow pipe extending up 1 inch through the bottom plate, and partly as "carry-over" which is collected in a dust-collection system consisting of a cold cyclone mounted on top of the reactor outside the brick chimney and a Peabody scrubber (not shown). The cyclone product is collected in a small gas-tight receiver which is emptied periodically during the test.

The Dutch oven and bottom plate which carries the gas intake, underflow connection, chlorine injection gun, and feed gun are attached by a flanged connection to the vertical reactor tube so that the whole assembly can be removed for cleaning and inspection.

OPERATING PROCEDURES

The Dutch oven was ignited and the inlet gas temperature brought to 1000°F. The external burners were then ignited and the reactor preheated to about 1000°F. while empty. The inlet gas was preheated throughout the test to supplement the external burners in counteracting the high radiation losses in the laboratory unit. Previous experience had shown that countering all of the radiation losses with the external burners causes hot spots on the reactor shell which produce agglomerates resulting in bed defluidization. The starting bed of salt was charged, the temperature brought to 1150°F., and liquor feed commenced. The conditions were stabilized at 1200°F. bed temperature.

Exit gases were analyzed periodically for CO_2 and O_2 by means of an Orsat gas analyzer. A sample of the stack gas was periodically bubbled through a silver nitrate solution to detect the presence of chloride (HCl). Occasionally, a sample was bubbled through a potassium iodide solution to test for chlorine.

FIRST TEST

The first test was designed to determine limits under the most favorable conditions. It was felt that if a liquor with 100% NaCl ash could not be run, then there was little hope of success. The liquor which was shipped to Dorr-Oliver was divided into two portions. Hydrochloric acid was added to one portion in an amount calculated to bring sodium and chlorine into stoichiometric balance. The test was begun with this liquor. During the start-up phase, some HCl was found to be present in the flue gas. It was felt that this was because too much hydrochloric acid had been added to the liquor so that an excess of chlorine was present. This was corrected by adding a small amount of the portion of liquor containing an excess of

sodium to the feed tank until no HCl carryover was observed. This "balanced" liquor was then used for the remainder of the test.

Emission of chlorides was insignificant after this adjustment of liquor composition was made. Periodic sampling for the presence of HCl and Cl_2 was carried out, but they were not detected in appreciable amounts. Samples of "underflow" bed material taken at different times during the test period did not give off CO_2 bubbles when placed in vinegar. This would indicate that very little Na_2CO_3 was present and that Na and Cl were essentially balanced at the stoichiometric level. Subsequent analysis of samples of the liquor indicated that it was balanced within the accuracy of the procedure used. This would seem to indicate that chlorine emissions are closely related to stoichiometry and that the excess of sodium needed to prevent emissions is small. In addition, no chlorine was detected in the flue gas. All of this is in basic agreement with thermodynamic predictions. Thus, atmospheric emission problems do not appear serious at temperatures of 1200°F.

The first test began smoothly enough using a starting bed of purchased salt. Pelletization appeared normal with very little ash material being found in the cyclone. However, some difficulty in maintaining a constant feed rate appeared and the Moyno pump stator required replacement after 6 hours of operation. A plug in the feed gun caused a shutdown one hour later. After restarting, it soon became obvious that the Buna N Moyno pump stator was unsuited for this liquor, as two new stators failed. When liquor feed rate began dropping with the last stator in, it was decided to raise the bed temperature to determine the defluidization temperature even though the turnover of bed material was much less than desired.

The bed defluidized between 1250 and 1280°F. This was somewhat lower than desired and was in the marginal range for successful commercial operation. However, it was felt that the value could be misleading because of the method used

to raise the bed temperature. It has been found by experience that the system works best if the bed is slightly hotter than surrounding metal so that the particles don't stick to the walls, distributor plates, etc. For this to occur, a substantial heat input must come from combustion of the liquor. In this first test, since it was not possible to feed the liquor into the bed at the desired rate, the bed temperature had to be raised by increasing the load on the air preheater and other gas burners. This situation could lead to some severe temperature distribution problems and hence a low value for the furnace temperature. Thus, there is a good probability that a sodium chloride bed can be operated at a temperature higher than 1280°F., but this remains to be demonstrated. The inability to get a reliable value for the fusion temperature on a bed containing a very high proportion of NaCl was the biggest disappointment of the first test.

After cooling, the restriction plate was taken down and the defluidized bed observed. There were degrees of fusion within the reactor with channels and holes at various places in the fused mass. There was a heavy accumulation of fused material around the restriction plate. This was a whitish to yellowish green in color. A sample was brought back to the Institute for analysis. Immediately above the restriction plate, the material was a good deal looser. Then higher in the bed, originating at the wall and projecting upward and inward, was more fused material. This was quite hard and difficult to chisel out. Some parts of it were an intense green color. A sample was brought back to the Institute. It is believed that the green color arises from chromium corrosion products originating from the chrome-plated rotor in the Moyno pump.

Four samples of bed material were brought back to the Institute for analysis. Two were from the 1200°F. portion of the test and two were fused material. The results are shown in Table I.

TABLE I

ANALYSES OF BED MATERIAL – FIRST TEST

S1: "Underflow" bed material taken early in test
S2: "Underflow" bed material taken later in test
S3: Fused material from near restriction plate
S4: Fused material from halfway up bed.

	S1	S2	S3	S4
Weight % Na_2CO_3[a]	0.1	0.6	0.9	1.3
Weight % NaCl[b]	99.3	99.4	97.9	97.1
Weight % other	0.6	0.0	1.2	1.6

[a] Determined by titration with acid.

[b] Determined by Volhard method for chloride.

The first test was only partly successful because of the difficulty with the pump. The results were both encouraging and discouraging. On the encouraging side were the lack of significant emissions of chlorine compounds and the good pelletizing behavior. The discouraging result was the intense fusion that occurred at a relatively low temperature with Na_2CO_3 levels of only about 1%. While not conclusive, this was the first indication that the presence of very small amounts of Na_2CO_3 could cause great difficulty.

SECOND TEST

It was recognized that satisfactory pumping had to be ensured before embarking on additional tests. A Viton stator for the Moyno pump was procured and tested for eight hours' continuous service with the liquor. It performed satisfactorily and so the second test was carried out.

The second test was designed to explore the width of the "operating window", that is, the amount of Na_2CO_3 that could be tolerated while maintaining satisfactory fluidization. Chlorine was injected directly into the bed in this test. The reason for chlorine injection was to try to use it as a means of control when the liquor contained an excess of sodium. It was recognized that it would be impossible to keep the liquor itself stoichiometrically balanced in a commercial pulping operation. What would be needed is a method for achieving a balance in the reactor itself so as to prevent defluidization. It was hoped that chlorine injection would serve this purpose.

For the second test, a new starting bed of purchased salt was charged to the reactor and the feed started on the "balanced" liquor remaining from the first test. Part of the original liquor sent to Dorr-Oliver (containing an excess of sodium) was then added to increase the Na_2CO_3 content of the liquor ash. Chlorine gas was then injected into the bed with the rate of addition increased until HCl appeared in the stack gas. The chlorine rate was then reduced until the HCl in the exit gas just disappeared. This procedure for controlling chlorine injection was used throughout the test. Chlorine gas itself was never detected in the flue gas, only HCl when the rate of addition was too high.

After approximately 15 hours of feeding, fluidization became progressively more sluggish. The space velocity was increased, but defluidization soon caused shutdown. The bed temperature was kept between 1160 and 1200°F., which is considered a definite minimum for good combustion. Since the bed defluidized at the minimum operating temperature, fluidized bed incineration cannot be recommended for this liquor unless some means for overcoming the stickiness problem can be found.

A summary of the operating conditions employed for the second test is given in Table II. A summary material balance is given in Table III. Results of chemical analyses of the bed material are given in Table IV.

TABLE II

OPERATING CONDITIONS – SECOND TEST

Bed temperature, °F.	1190
Freeboard temperature, °F.	1115
Inlet gas temperature, °F.	990
Liquor feed rate, lb./min.	0.74
Propane rate, SCFM	0.38
Air rate, SCFM	33.9
Chlorine rate, SCFM	0.30
Space velocity, ft./sec.	3.0
Bed depth, in.	53
Bed detention time, hr.	45
Fluid density, lb./ft.^{3}	56
Carryover, %	50
Excess air, %	30
Exit gas analysis	
CO_2, %	13.9
O_2, %	5.0

TABLE III

MATERIAL BALANCE – SECOND TEST

IN		
Starting bed, lb.	200	
Feed, lb., 711.3 x 50% x 41% =	145.8	
Total, lb.		345.8
OUT		
Underflow, lb.	33	
Cyclone, lb.	135	
Bed, lb.	211	
Scrubber, lb.	1.5	
Total, lb.		380.5
Nonclosure, %	9.6	

TABLE IV

ANALYSIS OF BED MATERIAL – SECOND TEST

S1: Underflow material about 3 hr. after startup
S2: Underflow material about 9 hr. after startup
S3: Sample of final bed after shutdown
S4: Sample of final bed after shutdown
S5: Sample of loosely flowing final bed material

	S1	S2	S3	S4	S5
Weight % Na_2CO_3	0.12	0.23	1.42	1.42	1.42
Weight % NaCl	97.6	96.6	94.1	95.1	95.2
Weight % other	2.3	3.2	4.5	3.5	3.4

Na_2CO_3 was determined by titration with acid.

NaCl was determined by Volhard chloride.

Because of the generally lower temperature in the second test, there was more unburned carbon in the bed which accounts for the higher value for other material.

It is clear that chlorine injection was not able to eliminate formation of Na_2CO_3 in the bed at injection rates which did not lead to HCl in the flue gas. This could be due to nonuniform mixing, insufficiently rapid chemical kinetics, or other reasons. Whatever the reason, it is not likely that chlorine injection would work significantly better on a commercial scale. It is equally clear that this system is very intolerant of Na_2CO_3. Carbonate levels as low as 1.5% of the ash are enough to cause bed stickiness and defluidization. The defluidization in the second test is even more surprising in view of the high carryover to the cyclone. This indicates a dusting condition occurring simultaneously with a strong tendency to defluidize. The net effect of all of these occurrences is not favorable to fluidized bed operation.

CONCLUSIONS

1. Fluidized bed combustion does not appear to be an attractive method for incineration of holopulp spent liquor because of a strong tendency for bed stickiness and defluidization when small amounts of Na_2CO_3 are present in the ash.

2. There were no significant air emissions during combustion at the 1200°F. level. Combustion products followed thermodynamic predictions very closely. Hydrogen chloride was the only gaseous chlorine compound formed when chlorine was present in excess.

3. It is likely that fluidized bed combustion could be carried out on a liquor with an excess of chlorine present. This could be achieved by adding hydrochloric acid to the liquor or by appropriate adjustment of pulping conditions. This would require the use of an HCl scrubber and a means for utilizing or disposing of the recovered HCl. Such a technique does not look too attractive at present.

4. There is a need to investigate the feasibility of alternative methods of combustion. Ideally, the approach should be able to handle a wide range of liquor compositions.

5. Since fluidized bed combustion of holopulp spent liquor does not look promising, there would appear to be little justification for us to rebuild our unit. Thus, plans to reconstruct our fluid bed system are shelved for the present.

PRESENT STATUS AND FUTURE WORK

Although the main effort has been directed toward fluidized beds, alternative methods of combustion have also been under consideration. Now that fluidized bed incineration does not look promising, these alternatives become much more important.

WORK AT BABCOCK & WILCOX

The problem of combustion of holopulp spent liquor was discussed with representatives of B&W in a meeting at the Alliance Research Center. The discussion included our concern with air emissions problems and materials problems as well as the failure of the fluid bed approach. Mention was made of the peculiar physical properties of the simulated liquor used at Dorr-Oliver. It was agreed that the major objective was to arrive at a judgment on the feasibility of combustion and a definition of system configuration.

The people at B&W felt that there was a need for some physical property data on holopulp liquors as well as data on combustibility. These data are used in evaluating different methods of introducing liquor into a furnace and in combustion models which they have developed. They have outlined a program of laboratory work on some liquors which we will supply them. Even though we could obtain much of these data ourselves it appears best to let B&W do the work since we are asking them to make a judgment on combustion feasibility and any feel they develop regarding the behavior of the material will be an aid to them.

At the completion of the testing program, B&W will supply us with all of the data generated in the laboratory program as well as the results of computer model calculations. They will also discuss the general combustibility of the liquor with emphasis on any problem areas. Finally, they will discuss the pros and cons of

various possible incineration concepts with emphasis on the one(s) most likely to be applied. Among the concepts to be considered are pile burning similar to kraft, suspension burning, cyclone firing, and submerged combustion. It has been estimated that the program can be completed in four to six weeks after the liquor is received by B&W.

FUTURE WORK

We are currently in the process of preparing the liquor for shipment to B&W. One batch of liquor has been prepared according to our conventional pulping approach. A second batch is nearing completion containing a greater proportion of sodium. These liquors will be sent to Babcock & Wilcox as soon as they are ready.

Planning for additional work on combustion will await the outcome of the research program at B&W.

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